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(54) Image intensifier system operated in a pulsed manner

(57) A repetitively switched optical shutter (3) in the field of view of an observer optionally controls the light, from a pulsed source, which is received by an image intensifier (2). The shutter (3) may be used in front of an image intensifier (2) so as to control the light from a pulse light source (4) which reaches the image intensifier.

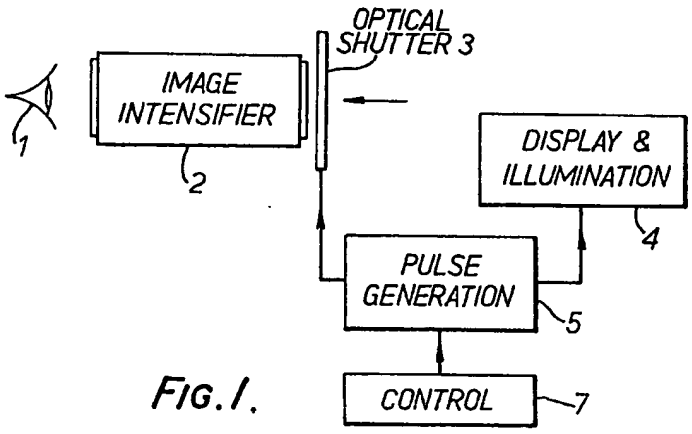

FIG. 1.

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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

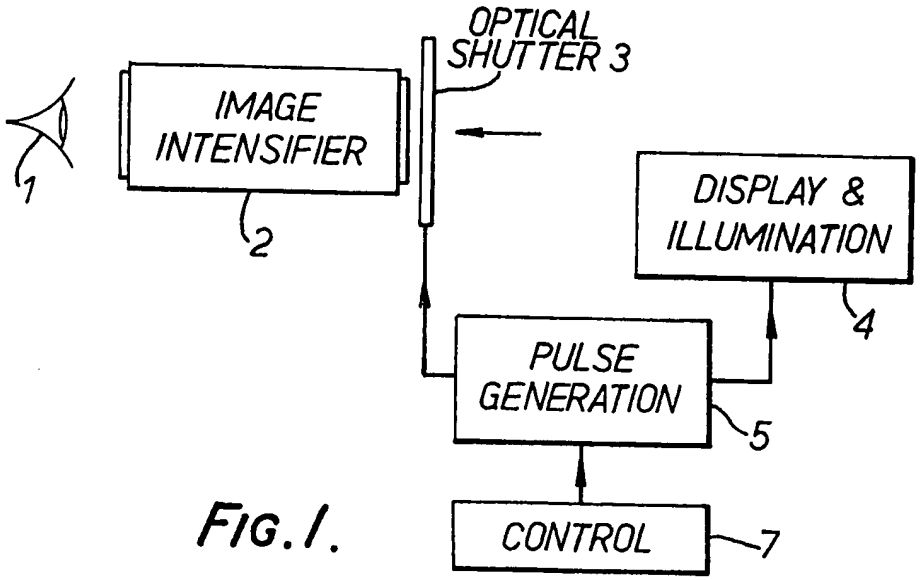

FIG. 1.

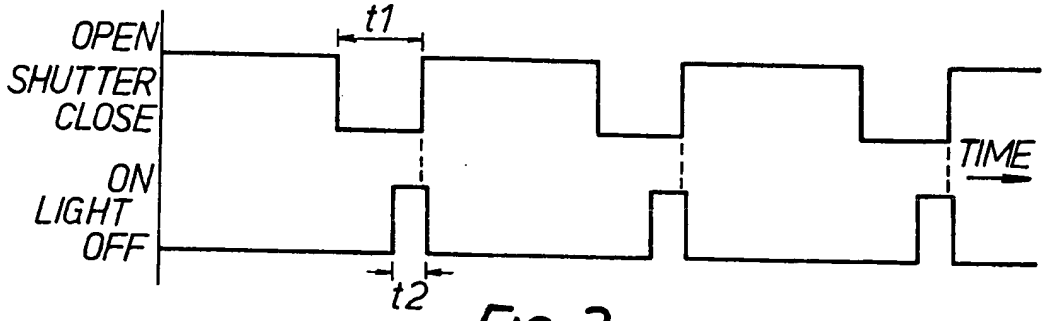

FIG. 2.

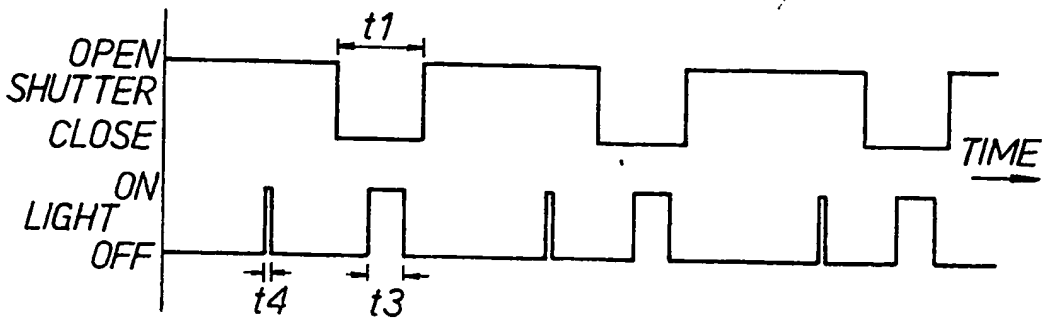

FIG. 3.

SPECIFICATION

Improvements in or relating to optical systems

This invention relates to optical systems in which a scene is to be viewed under adverse lighting conditions with the use of an image intensifier.

Typically, an image intensifier receives a relatively faint image which is converted into a corresponding pattern of charges or electrons from which a very much brighter image is generated for presentation to an observer. Image intensifier systems are very useful for permitting observation of dimly lit scenes and objects, since image intensifiers are capable of providing a very high degree of optical amplification so as to permit the eye to see in detail what, to the unaided eye, would merely be darkness. For example, clear and detailed vision is possible under conditions illuminated only by natural starlight. A difficulty which arises in the use of an image intensifier is that the performance can be impaired if an excessive level of illumination is allowed to fall upon its input optical surface. In this context, an "excessive" level may be one which is quite acceptable to the eye and may in normal circumstances be regarded as being fairly dim, but which because of the extreme sensitivity of the image intensifier, can cause gross overload.

It has been proposed to restrict the spectral sensitivity of an image intensifier by means of colour selective filters and to attenuate corresponding radiation from localised sources of radiation by means of a further spectral filter complementary to the first. However, the use of filters reduces the overall sensitivity of an image intensifier both due to the loss of that part of the spectral response in the attenuating region of the filter and by the insertion loss which occurs in the nominally transmitting region.

According to this invention, an optical system includes an image intensifier; a scource of illumination; means for operating the intensifier in a pulsed manner so that it responds to applied illumination only during selected recurring periods; means for pulsing the source of illumination so that light is emitted therefrom only during selected recurring periods; and means for arranging that the respective two periods have a controlled common time element so that said image intensifier receives a controlled light level from said source.

By carefully controlling the magnitude of the common time element, i.e. the amount of time during which the source of illumination and the image intensifier are active simultaneously, it can be ensured that the image intensifier does not respond to an excessive level of light from a relatively bright source and more importantly, the level of the illumination originating from the source is no longer of direct relevance so far as the sensitivity of the image intensifier is concerned. Thus, the image intensifier can be used by an operator in an environment which is quite brightly lit provided that the background illumination originates from a source or sources of light which are pulsed in accordance with the above manner, with the degree of time overlap being shorter the brighter the background illumination. In this way, the other personnel may operate in levels of normal illumination and use illuminated instruments in a conventional manner, whilst the image intensifier can continue to respond to extremely low levels of illumination without risk of overload.

The operation of the image intensifier is not restricted to the visible range, but can extend to the infra-red and ultra-violet ends of the spectrum, and the term "illumination" is to be construed accordingly. As the image intensifiers are used by human operators, it is very desirable that the repetition rates at which the system is operated are above the flicker frequency of the eye, so that an operator is not directly aware of the pulsed nature of the operation of the system.

The invention is further described by way of example with reference to the accompanying drawing in which:-

Figure 1 illustrates an optical system in accordance with the present invention, and

Figures 2 and *3* are explanatory diagrams.

Referring to Figure 1, there is shown therein an optical image intensifier system which is suitable for use in the cockpit of an aircraft. Particularly at night it is desirable for crew members to use an image intensifier to enhance the visibility of an external scene, which may be lit only be natural starlight. Light from the external dimly lit scene is viewed by an observer 1 via an image intensifier 2, and an optical shutter 3 which is placed in front of the photo sensitive surface of the image intensifier 2 so as to control the light falling upon it. Light from various instruments and background illumination is invariably present in a cockpit and is necessary to permit the pilot and crew members to perform their essential functions. Light of this kind is indicated as originating from the source 4.

Although the display light and background illumination may be at a relatively very low level, nevertheless, their presence can cause serious degradation of the operation of the image intensifier 2, as such devices can be extremely sensitive to light (and in the specialised context of such an intensifier the background illumination is regarded as bright). An image intensifier is able to view a scene illuminated only by natural starlight and to so amplify it as to present it to a viewer as though is were normal daylight scene. Even relatively low level light generated within a cockpit, or adjacent to the light receiving surface of the image intensifier 2, can cause gross overloading of the optical capabilities of the image intensifier if the whole of it is allowed to reach the imput surface of the image intensifier.

This difficulty is overcome by controlling the optical shutter 3 and the display and illumination source 4 by means of a common pulses generator 5. The generator 5 is operative to energise the illumination source 4 during periods which occur mainly whilst the optical shutter 3 is closed, i.e. non-transmissive so that light is prevented from reaching the image intensifier 2. The pulse repetition periods, and the duration of the pulses pro-

duced by the generator 5 are determined by a control circuit 7. Typically the shutter 3 is a liquid crystal device of a kind which can be rapidly switched between opaque and transparent states by the application of suitable signals.

Typical waveforms are illustrated in Figure 2, and it will be seen that the shutter is rendered open, i.e. light transmissive, for most of the time, but it is closed for short intervals of duration t1. The illumination source 4 is rendered active only for very short periods each of duration t2 and it is arranged that the periods t2 have a small time overlap with the period t1. This ensures that the light which is generated by the illumination source 4 and which is allowed to fall upon the input surface of the image intensifier 2 has a very low controlled mean level. In practice, any instrument lights and background illumination can be constituted by solid state light sources, such as light emitting diodes, and it is possible to operate such devices with an extremely high mark to space ratio. The box 4 represents all of such sources of light, but in practice the individual sources will be spaced apart from each other at different locations. For example, the period for which the source 4 is energised so as to emit light may be between 1- and 0.1- of the total time, yet the pulses of light emitted during these very short periods can be very intense so as to provide an average level of illumination which is quite acceptable. If the source of illumination is of the kind which cannot be turned on and off rapidly, then it could incorporate, or be used in conjunction with, an optical shutter similar to shutter 3.

The repetition rate of the switching waveforms applied by the pulse generator 5 are both the same and is made sufficiently rapid so that flicker is not apparent to an observer. In practice, the repetition frequency will be of the order of 60 Hz or higher. The duration of period t2, and its overlap with period t1 can both be varied to take into account variations in the intensity of the local light and/or the external scene viewed via the intensifier. In practice it may be more convenient for the period t2 to partially overlap the start of period t1, rather than its end as shown in Figure 2.

The mode of operation illustrated in Figure 2 requires fairly precise control of the relative phasing of the operation of the shutter and the light source so as to ensure that the degree of overlap during which the shutter is open to light from this source is correct, i.e. great enough to be useful, but small enough not to overload an image intensifier.

Figure 3 shows a mode of operation in which the main 'on' period t3 of the light source is wholly within the 'close' period t1 of the shutter so that no light corresponding to the pulse of period t3 reaches the image intensifier. The light source additionally generates a very short pulse of light of period t4 whilst the shutter is open - it is now necessary only to accurately control the duration of this short pulse as its instant of occurance is not critical, and in particular no difficult task of relative phasing arises, it merely being necessary to ensure that the pulse t4 occurs wholly within the 'open' period of the shutter to give a common time element.

By allowing just a small amount of the light from a local source 4 to be accepted by the image intensifier, a person using the image intensifier to view a very dark scene will also be able to accept locally generally visual information; e.g. in an aircraft cockpit he will also be able to see optical instrumentation and read visual display pannels or the like.

Although in Figure 1 the periods during which the image intensifier receives external light are determined by the optical shutter, this need not necessarily be the case. Typically, the optical shutter 3 will be constituted by a liquid crystal light transmissive device, as previously mentioned. Such devices are now capable of operating at the required speed and whilst they are in an optically transmissive state their optical attenuation is very low. Alternatively, however, the control signal from the pulse generator 5 can be applied directly to the image intensifier so that its optically sensitive surface does not respond to incident light whilst it is in an "off" state, so that the presence of the optical shutter is no longer required. Direct gating of the image intensifer can present advantages, as the liquid crystal material causes small but significant insertion loss of incident light.

CLAIMS

1. An optical system including an image intensifier; a source of illumination; means for operating the intensifier in a pulsed manner so that it responds to applied ilumination only during selected recurring periods; means for pulsing the source of illumination so that light is emitted therefrom only during selected recurring periods; and means for arranging that the respective periods have a controlled common time element so that said image intensifier receives a controlled light level from said source.

2. A system as claimed in claim 1 and wherein the common time element is small as compared to the duration of both periods.

3. A system as claimed in claim 2 and wherein one period partially overlaps the other period.

4. A system as claimed in claim 2 and wherein the source of illumination is pulsed on for a certain time whilst the intensifier is not responsive, and is pulsed on for a short time whilst it is responsive to applied illumination.

5. A system as claimed in any of the preceding claims and wherein the pulse repetition rates of said periods are the same.

6. A system as claimed in any of the preceding claims and wherein the means for operating the image intensifier in a pulsed manner includes an optical shutter located in front of the input surface of the image intensifer, the shutter comprising a switchable liquid crystal device.

7. An optical system substantially as illustrated in and described with reference to Figures 1 and 2 or 3 of the accompanying drawing.

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